NOTES ON PEARL FORMATION AND JAPANESE CULTURE PEARLS.

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(PLATES VII AND VIII.)

The study of pearl oysters and the problems presented by the formation of pearls demand an acquaintance with the distinction between pearls and " blisters ", or excrescences on the shell surfaces. All pearls are formed within the tissues of the mollusc, but they frequently pass out and become included between the animal and the shell, when they are treated in the same manner as any foreign object in that position. They are joined to and embedded in the shell by successive layers of nacre, or other shell-substance. These excrescences are gradually reduced in height by the successive layers of nacre covering the foreign body, being thinner at the top than at the base or plane of the shell (Pl. VIII, f. 5). " Decreasing blisters " are represented on Pl. VII, Figs. 1, 2, and 3. Fig. 4 represents different features and represents an " increasing blister " or barrier raised as a defence against penetration by a boring bivalve from the outside ; and the layers of nacre are thicker at the top than at the base. In the event of the borer working vertically the shell is usually pierced ; but in most cases the borer works at an angle, and the pearl oyster is able to increase the height of the blister quickly enough to prevent complete penetration. When the borer is completely within the substance of the shell the entrance it has left behind itself often becomes choked with mud, which prevents the entry of sea-water, in which case the borer perishes and the pearl oyster then reduces the height of the blister in the same way as described in the three preceding instances. Small blisters are thus often completely levelled down in the growing shell.

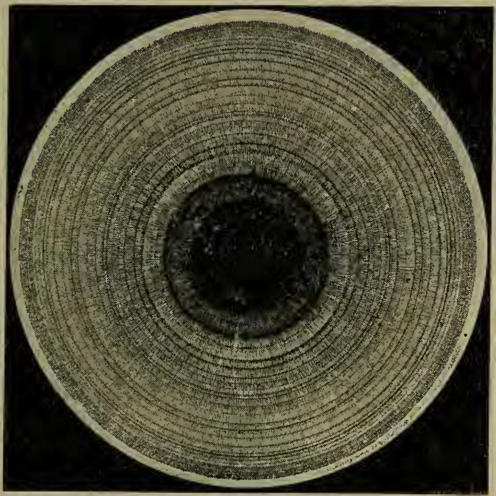
If there is a hole at the back of the shell opposite to a blister the pearler takes no further interest in it ; but if there has been no borer at work the pearler punches out the blister by a series of holes round it with a steel punch, and by smart but careful tapping with a hammer laterally the blister will disclose the nature of its contents by splitting in two at the point where the foreign substance which lodged against the shell surface was attached and covered by the successive layers of nacre. These true blisters may contain a crab (Fig. 2) or stray shell (Fig. 1) or stone or a pearl (Fig. 3) escaped from the tissues of the oyster, or they may be hollow and foul-smelling when opened—in which case an animal or vegetable object was entombed and has decomposed and left no trace of its identity.

There is no direct evidence as to the frequency of shell secretion. When young the lateral growth of the animal is so rapid that the secretion of layers of nacre, each overlapping the other outwards towards and over the horny lip of the shell and increasing the diameter of the shell, must be a continuous function ; but after full growth it may be doubted whether the layers follow one another so rapidly. If a pearl oyster perishes the animal quickly disappears, being eaten by fish, crabs and small molluscs, and within twenty-four hours in warm tropical waters the shell will lose its brilliancy and become quite dull or "dead" owing to the chemical action of the salt water. When the mother-of-pearl oyster is alive and open the two mantle lobes cling closely to the surfaces of the upper and lower shells, excluding the sea-water from direct contact with the shell, but leaving a considerable space for it to fill between the two mantle lobes. It is obvious, therefore, that the larval pearl-inducing parasite or any other intruding object must first enter *between* the mantle lobes and not between the mantle and the shell.

The mantle lobes' adhesion to the shell surfaces is so strong that considerable leverage with the blade of the knife has to be exerted to force them apart, and it is not improbable that a certain degree of suction action prevails, in addition to the presence of a slime of a mucilagenous character which promotes adhesion. It is quite obscure how a stray shell or dead crab or other object which is found in a blister attained access to the shell surface beneath the mantle lobe. Nothing is known of the activities of the oyster when it is closed, or what convolutions of the animal occur, but it is quite possible that occasionally each mantle lobe is turned inwards, bringing the slimy external epidermis into contact with the inner clean ciliated epidermis of the cavity in order to clear it of intruders, large or small. In this manner cestode larvæ piercing the cavity lining would enter under different conditions to those piercing the outer lining.

The magnified section in Fig. 5 (Pl. VIII) of the artificially produced Japanese blisters represents a special adaptation of a custom amongst Chinese from time immemorial to produce figures of Buddha, and other objects, as blisters in shells : the same thing was done by Saville Kent in Australia. The configuration of the layers of nacre in this figure exemplifies the process of reduction in height.

Fig. 6 (Pl. VIII) is a highly magnified section of what there is reason to believe is actually what it is represented to be—a mother-of-pearl bead covered with layers of nacre within the tissues of a living pearl oyster and converted into a pearl. The remarkable difference between these layers both in thickness and in regularity and those in the two following Australian pearls is of importance. These new Japanese culture pearls vary of course in quality, but the one from which this section was cut was of about 5 grains much above the ordinary quality. Mr. Mikimoto, the originator of the enterprise, does not profess to produce anything much larger than 7 grains. According to the specification of his American patent, taken out in 1919, a portion of the shell-secreting epidermis is taken from the mantle of a living oyster and formed into a little sac within which a bead of mother-of-pearl is inserted, the sac tied up and inserted into an incision made in a second oyster, the ligature being then removed, the wound treated with an antiseptic and an astringent, and the oyster returned to the sea. They are operated on when 3 years old, and opened for the result at 7 years, the maximum age being about 10 years. This artificial, grafted sac is in imitation of the cyst which experts declare is naturally made round the nucleus of all fine pearls. Obviously the artificial sac must be an inferior production to that formed by nature, and this would account for the irregularity of the concentric layers of pearly matter compared with the remarkable regularity shown in Fig. 7.



Section (× 11) of a very perfect pearl, reproduced by the kind permission of its possessor, Mr. J. G. Bradbury.

There is no particular reason why an operation successful in making 7 grain pearls in the Japanese small 3-inch pearl oyster should not be adopted on the large Australian pearl oyster running up to 15 inches in diameter and producing pearls exceeding even 100 grains; but Mr. Mikimoto must improve his methods greatly before he can produce anything in the shape of a perfectly round pearl of say 40 grains, for which as much as £5,000 has frequently been paid. The deviation from the true spherical shape in the 5 grain (Fig. 6) would be of very serious detriment in a 40 grain pearl, which to fetch any fancy price must roll perfectly straight without wobbling a hair's breadth. (Cf. Text figure.)

It is difficult to understand why Mr. Mikimoto should have patented and thereby published the details of his process. The grafting operation is one of a very delicate nature, requiring quick and deft workmanship more likely to be attained in an Asiatic race in which the cultivation of the arts is instinctive, than in Western races; and the implantation of the artificial sac in the body proper or "under the liver" in the posterior part of the living oyster, where the secretion of pure white pearl is to be secured, is a much more difficult matter than in the mantle in the anterior region, where in *Pinctada martensii*, Dkr., there is great probability of the pearl being of a decidedly yellowish tinge. Nevertheless, the grafting of shell-secreting epidermis and its conversion into a pearl-secreting sac, marvellous as it may sound, is inferior in novelty to and less remarkable to pathologists than the experiments performed at Plymouth by Mr. G. H. Drew on *Pecten* and the formation of a cyst within the adductor muscle of one scallop by the conversion into columnar ciliated epithelium of the inner layer of fibroblasts, stimulated by the artificial introduction of a fragment of living ovarian tissue from a second scallop, such fragment (acting as a nucleus) degenerating in six days leaving a residue of a few blood cells and granular matter. This marks a new departure in metaplasia, as will be seen from the following conclusions culled from Mr. Drew's paper [1] :—

Ribbert, 1908. "Only tissues that, while externally different, possess nevertheless the same histogenetic capacities can undergo metaplasia one into the other.

On the other hand,

Leo Loeb, 1899, records that in cases of epithelial regeneration in vertebrates, he has observed epithelial cells migrate into underlying tissues, and take on the appearance of fibroblasts.

Drew, 1910, on *Cardium norvegicum*. Corpuscles coming into contact with a rough foreign body or injured tissue possess the power of agglutination and forming a compact plasmodial mass, and the same in *Pecten*.

Sir Ray Lankester, 1886–93, shows that certain corpuscles in *Ostrea edulis* have a phagocytic action on diatoms and minute green algæ.

Drew, 1910, Corpuscles of *Cardium norvegicum* have phagocytic action on bacteria and are attracted towards extracts of dead tissues.

From a pearl student's point of view Mr. Drew's experiments would have been more interesting if the insertion had been made in the body proper, or in the mantle lobes, rather than in the adductor muscle, the pearls from which in a pearl oyster are of

[1] Journal of Experimental Zoology, vol. x, 1911 (U.S.).

a different and valueless character as compared with those formed in the softer parts of the oyster ; the former being more of the nature of concretions and the latter alone being cyst-pearls.

Dr. H. Lyster Jameson, who has made the nuclei of pearls his special study, says that apart from those of trematode origin they range from diatoms and fragments of radiolarian shells to sponge spicules.[1] He also is of opinion that " the immediate cause of the pearl is not the mechanical irritation caused by the body of the parasite, but rather the toxic properties of its secretions, which lead to the pathological changes (formation of the tumours that we call pearl-sacs) in the tissues." [2]

In a letter to the *Times* (7th May, 1921) Sir Arthur E. Shipley, in commenting on the new Japanese culture pearls, refers to the outer shell-secreting epidermis of the mantle, and remarked that " should the intrusive body press on into the interior of the mollusc it will in some cases carry with it a portion of the epidermis, which will in time form a little cyst around it ", secretion of nacre following and the formation of a pearl. It is difficult, however, to accept this proposition if it is meant to cover all cyst-pearls.

On one occasion an Australian mother-of-pearl oyster was found which not only contained free pearls enough to fill a sherry glass, but both shell surfaces were studded thickly with embedded pearls of all sizes varying up to that of wrens' eggs. It is difficult to reconcile this as probable under Sir Arthur Shipley's proposition ; and if endogenous larval reproduction, as vouched for by Mr. Southwell in Ceylon pearl oysters, accounted for this extraordinary amount of pearl formation, the suggestion occurs that such wholesale cyst formation was attributable to metaplastic action closely akin to Mr. Drew's experiences in *Pecten*. The same comment may be advanced touching the non-pearl-bearing, " fibrous," or " connective tissue cysts " containing cestode larvæ, which predominate so largely in Ceylon oysters over the actual pearl-bearing epithelial or ectodermal sac.

It is not definitely stated by anyone that *foreign* blisters occur on the upper shell of a pearl oyster, but *pearl* blisters certainly occur there, and the fact is one of special interest. No biologist has explained how a pearl that has escaped from its sac passes through the inner or outer epidermis, but some new information may be expected to be published shortly as to foreign bodies being passed through the outer part of the body wall of oysters and " blistered ".

The controversy that exists as to the identity of the parasite, or parasites to which the formation of fine Ceylon pearls is to be attributed is still acute. Cestode larvæ are found within the tissues of the pearl oysters, but Dr. Jameson maintained (1912) that " no

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[1] Nature, 26th May, 1921.
[2] Jameson, Proc. Zool. Soc., 1912, p. 329.

satisfactory instance is recorded of the cestode parasite being observed surrounded by an *epidermal* sac" (Proc. Zool. Soc., 1912, p. 273). It has been still more doubtful whether the larval intruder ever developed within a cyst, or within a pearl into the adult worm, whose proper final host was the devourer of the oyster. The precise identity of the worm or worms and the host in tropical waters are still unknown; but evidence has recently been found of a pearl containing the complete remains of what was supposed to be a fully developed worm within its nucleus. This pearl was sectioned, as shown in Fig. 8 (Pl. VIII), and the section revealed under the microscope the figure of the letter S. After the section was sent for a magnified photograph the lower bend of the S was found to have disappeared. Later, unsuspicious of danger, the same process was repeated, with the result that the upper part disappeared, leaving barely sufficient for identification of actual vermian remains. This disaster is undoubtedly attributable to heat engendered in the photographic process, but the original figure was seen by Dr. G. T. Prior at the Natural History Museum, as well as by others, one of whom asserted he saw the "horns" and tail—and he unhesitatingly picked out Fig. 70 on Plate IV of "The Parasites of the Pearl Oyster", by Sir Arthur Shipley, as of similar appearance. Fig. 70 represents the head and "horns" of the adult *Tetrarhyncus minimus*, but having regard to Figs. 19 and 22, representing the "oldest larval stage of *Tetrarhyncus unionifactor*, met with in the tissues of the pearl oyster", there is no certainty as to the specimen found being actually a fully developed worm. The similarity also between *T. minimus* and *T. unionifactor* in the "horns" renders precise identification from memory uncertain.

EXPLANATION OF PLATE VII.

Blister Pearls from *Pinctada* [= *Meleagrina*] *maxima* (Jameson).

Fig. 1*a*, *b*. Natural blister (nat. size) containing a stray shell.
,, 2*a*, *b*. ,, ,, ,, ,, *Pinnoteres*.
,, 2*c*. ,, ,, (× 3) ,, ,,
Reproduced by kind permission of Mr. A. Lanburn.
,, 3*a*, *b*. Natural blister (nat. size) containing a pearl.
,, 4*a*, *b*. ,, ,, ,, formed in the lower valve as a defence against the intrusion of a shell-boring bivalve.

EXPLANATION OF PLATE VIII.

Sections of Culture and Natural Pearls.

Fig. 5. Section of artificially produced blister from Japanese pearl oyster (*Pinctada martensii*, Dkr.), sold largely hitherto as "Culture Pearls" and utilized as half-pearls in cheap jewellery.
,, 6. Magnified section of a 5 grain Japanese culture pearl (⅜ in. in diam.) containing a mother-of-pearl bead centre.
,, 7. Magnified section of Australian pearl (¼ in. in diam.) in a shell blister.
,, 8. Magnified section of Australian pearl (¼ in. in diam. min.) of dull surface, showing removal of a number of skins by a knife on the straight side for the purpose of testing the quality of the skins below.